ELECTRONICALLY COMMUTABLE MOTOR
HAVING OVERLOAD PROTECTION

Field Of The Invention

The present invention relates to an electronically commutable motor whose output
stages are controllable by an electronic control unit, using PWM signals, and are
feedable from a supply voltage source.

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Background Information

In motors of this type, the electronic control unit supplies power to the motor output
stages, which ordinarily include semiconductor switches and windings. The control
unit is usually designed for bidirectional operating conditions. If the motor drives a

10 fan, for example, the current rises in proportion to the squared motor speed, while
the motor speed rises in linear proportion to the supply voltage. If fans of this type
are used in a motor vehicle and fed from the vehicle battery, the motors are
designed for a nominal voltage of 13 V, for example, but must operate dependably
at a voltage of up to 16V, for example. The fan must provide the necessary air

15 capacity at the nominal voltage. The higher air capacity available at higher battery
voltages is therefore superfluous. However, these stipulations mean that the motor
and the electronic components must be designed for higher performance ratings
around 16V.

20 ## Summary Of The Invention

An object of the present invention is to provide an electronically commutable motor
that is designed so that its electronic components are limited to the load specified by
the nominal voltage and are protected against overloading even when the supply
voltage exceeds the nominal voltage.

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This object is achieved according to the present invention by enabling the pulse

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width of the PWM control signals for the output stages to be reduced, at least upon exceeding the motor nominal voltage, to a width that prevents overloading of the motor and electronic components by limiting the motor output, as a function of the magnitude of the supply voltage and the specified setpoint for the PWM control

5   signals.

By influencing the PWM control signals for the motor output stages in this manner, the maximum load is defined by the nominal voltage and the maximum setpoint and cannot increase any further even with high supply voltages. The motor and its

10   electronic components therefore need to be designed only for this load and are protected against overloads.

A design of this type also enables the pulse width to be reduced in such a way that the pulse width is reduced in linear or nonlinear proportion to the rising supply

15   voltage; however, it is also possible for the pulse width to decrease at an increasing rate with an increasing specified setpoint and rising supply voltage. This latter instance advantageously makes use of the fact that a smaller specified setpoint reduces the load on the motor and its components, due to lower currents.

20   According to one embodiment, the pulse width reduction may be incorporated into the control unit by assigning the control unit a correction unit that forwards, to the motor output stages, the PWM control signals for the motor output stages determined according to the specified setpoint, either unchanged or as reduced PWM control signals, as a function of the magnitude of the supply voltage; and by

25   enabling the PWM control signals for the motor output stages determined by the control unit on the basis of the specified setpoint to be forwarded unchanged to the output stages until the motor nominal voltage is reached, with their pulse width being reduced according to the setting provided by the correction unit only when the supply voltage begins to increase.

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The correction unit may be integrated into the control unit. In this case, the control unit delivers, to the motor end stages, the PWM control signals, either unchanged or with a reduced pulse width, as a function of the magnitude of the supply voltage.

5   With this protective circuit, it is possible to detect the motor speed instead of the supply voltage and use it to reduce the pulse width of the PWM control signals. According to the present invention, both values – the supply voltage and the speed – are used to reduce the pulse width of the PWM control signals.

10   Brief Description Of The Drawings
Figure 1 shows a block diagram of the control unit of an electronically commutable motor with a reduction in the pulse width of the PWM control signals.

Figure 2 shows the motor characteristics with power limiting.

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Figure 3 shows the PWM control signal with a normal and reduced pulse width.

Figure 4 shows the pulse width variation as a function of the supply voltage.

20   Figure 5 shows the pulse width variation as a function of the supply voltage with different specified setpoints for the PWM control signals.

Detailed Desciption
Figure 1 shows a schematic representation of the main units of the electronically

25   commutable motor according to the present invention. However, this does not represent a design delimitation, but serves merely to explain the functions.

Control unit STE is provided with a setpoint $PWM_{setpoint}$ for the PWM control signals of the motor. The setpoint may be specified manually, for example using a

30   potentiometer, and serves to specify a higher or lower speed for the fan driven by

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the motor. The motor characteristic, indicated by function $PWM_{end} = f (PWM_{setpoint})$, is stored in control unit STE, where PWM_{end} represents the PWM control signal for output stages EST of the motor and specifies pulse width ID of the control signal according to Figure 3.

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As shown in Figure 2, this yields different motor characteristics I-f (M) and N = f (M) for nominal voltage U_{nom} = 13 V and maximum supply voltage U_{max} = 16 V, where I = current, M = torque, and N = speed. Maximum working point A1 having maximum speed N1, maximum current I1 and maximum torque M1 is specified as the load limit

10   value at nominal voltage U_{nom}. An increase in the supply voltage to maximum value U_{max} would yield a maximum working point A2 having maximum current I2, maximum speed N2 and maximum torque M2. To avoid having to design the motor and its electronic components for these maximum loads, activation of output stages EST of the motor is corrected, as indicated by correction unit KE in Figure 1. Value PWM_{end}

15   for the PWM signal of output stages EST determined by control unit STE for setpoint $PWM_{setpoint}$ is modified by correction unit KE so that working point A2 returns to working point A1:

This takes place as a function of the magnitude of supply voltage U_{batt}, as indicated

20   by PWM control signal PWM'_{end} output by correction unit KE. As shown in Figure 3, pulse width ID is reduced to pulse width ID' in linear (a) or nonlinear (b) proportion to the further rise in supply voltage U_{batt}, more or less shortly after nominal voltage U_{nom} is exceeded, as shown in Figure 4.

25   The degree of reduction may also vary in conjunction with specified setpoint $PWM_{setpoint}$, as shown in Figure 5. With a small setpoint $PWM_{setpoint}$, the reduction decreases more gradually than with a larger setpoint, as indicated in Figure 5 by the different curves of reduced pulse widths ID' of PWM control signals PWM'_{end} as a function of supply voltage U_{batt}.

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Note, in addition, that pulse width ID may be corrected by control unit STE itself, and speed N may be used instead of supply voltage U_{batt} and/or in addition to supply voltage U_{batt} as the parameter for reducing pulse width ID.